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Pluralizing 'Eurocentric' Technology Discourses 'Back Home':

Technology and Societal Challenges in Western Europe

Erik van der Vleuten

If a global history of technology is to break with 'universalizing, diffusionist and Eurocentric models' and restore a plurality of conceptions of technique in diverse socioecological contexts, as this book's introduction desires, it might benefit from a discussion of what those 'models' were about. To that purpose this chapter revisits the history of 'Western' dominant discourses about technology in relation to society and nature, with a particular focus on engineering communities in Western Europe and its diaspora — notably North America and other (former) colonies.

As we shall see, successive engineering discourses have time and again emphasized the broader relationship between technology, society, and nature, and indeed often in quite universalistic terms. Since the birth of engineering as a civil discipline and profession in the decades around the turn of the nineteenth century, that discipline has been legitimated with reference to the transformative power of innovation to solve major economic, social, political, and — most recently — environmental challenges worldwide. Today such a discourse once more pervades the engineering community and beyond: '[p]eople face a host of global challenges that must be addressed through long-term and innovative education, research, and engineering solutions', state the presidents of the US National Academy of Engineering, the UK Royal Academy of Engineering, and the Chinese Academy of Engineering in a joint manifesto-like article in 2016 (Mote, Dowling, Zhou, 2016: 4). The three presidents explain how, over the past decade or so, the engineering community has translated today's key global challenges (as represented by e.g. the UN's Sustainable Development Goals and the EU's societal challenges programme) into the so-called 'Grand Challenges for Engineering', spurring the community to work on solutions so that 'human life as we know it can continue on this planet' (Mote, Dowling, Zhou, 2016: 4). This programme continues to make a great imprint on engineering education, research funders, and tech company mission statements worldwide.

That present-day discourse to save humanity and the planet through innovation may be regarded as sympathetic or self-interested depending on one's perspective. Either way it illustrates how universalistic discourses may monopolize problem and solution definitions, obscuring alternative problem experiences, definitions, and solutions of other social groups. This chapter will therefore not only revisit the history of ‘Western’ dominant engineering discourses that supposedly became so influential throughout the world (indeed, so much so that it needs a global history turn to restore lost alternatives); it will also problematize these discourses’ supposed universalism ‘back home’. It does so by highlighting not one, but a number of potentially conflicting Western engineering discourses on technology and socioecological change. In addition, it discusses how various social groups appropriated those discourses, at times articulating their problems and solutions very differently and accordingly taking technical change, its societal implications, and its governance into widely diverging directions. In order to do so, this chapter must explicitly avoid *a priori* definitions of such concepts as ‘technology’, ‘humanity’, ‘society’, or ‘grand challenges’, and instead trace how diverse historical actors have filled these and related notions with meaning — and acted upon those meanings.

For want of space, the following sections focus on four pivotal ‘Western’ engineering discourses (each of which came in several varieties). These four discourses overlapped and co-existed in time and space. Still, they particularly resonated in different periods in (West) European history, and this chapter will discuss and unpack each discourse in the specific historical context that brought it to prominence. The second section discusses the societal promises of technology which, despite repeated technological conflicts and calamities, became widely shared and celebrated in the long nineteenth century. The third section addresses pessimistic discourses on technology’s destructive ‘unintended consequences’ that rose to prominence in Europe’s so-called thirty years’ crisis between 1914 and 1945. The fourth and fifth sections discuss two sets of discourse on how to save technology’s promises from its negative unintended consequences: technocratic innovation discourses thrived in the postwar decades, as did diverse (and mutually conflicting) brands of participatory innovation discourse that emerged in Europe’s counterculture years but stretched deeply into the neoliberal age.

Before we continue, a brief note on geography is warranted. This chapter was tasked to discuss the history of technology within the mesoregion known (particularly during large parts of the twentieth century) as ‘Western Europe’. It does so by discussing dominant engineering discourses on technology and societal change in that region, but in doing so, it draws primarily upon two decades of research in the pan-European history of technology association *Tensions of Europe*. That association birthed a transnational European history of technology conception that rejects *a priori* geographical delineations and instead spotlights connections and circulations across national, regional, and continental boundaries, notably including transatlantic and (post)colonial linkages (Misa, Schot, 2005; van der Vleuten, 2008). Accordingly, this chapter, though centring on engineering discourses found in what loosely (but never unproblematically) may be termed ‘Western Europe’, repeatedly traces the histories of those discourses beyond geographically or politically bounded notions of the subcontinent.

Promises and Appropriations

The first of these ‘universalistic and Eurocentric’ engineering discourses was born in the decades around the turn of the nineteenth century. That discourse underscored that even in the richest part of the world, in northwestern Europe, the great majority of people lived in poverty; hunger and malnutrition, poor clothing and housing, infectious diseases and low life expectancies ruled the day. However, in these decades a new professional breed of civil engineers — military engineering had much older roots — and other believers increasingly argued that modern technology of the kind pioneered in the British Industrial Revolution could and would change all that. The promise of progress through technology became a credo of the long nineteenth century, and by the end of that period the vast majority of Western European populations had indeed gained access to more and better food, housing, clothing, health, mobility, and energy than ever before.

Illustrating this discourse of promise, we here limit ourselves to two iconic examples from the first half of the nineteenth century. First, historians have credited the writings of Michel Chevalier in the early 1830s as a particularly pertinent and influential articulation of the ideology of social progress through technology. A recent graduate from Paris' prominent engineering schools, Chevalier combined the modernisation thinking of young engineers of his generation with the hopes of the Saint Simonian 'religion of humanity' seeking peaceful roads to modernisation and improving the human condition. As the Saint Simonian movement journal's editor, Chevalier gained a platform to articulate his views. Here he shared the problem analysis of his peers: Europe had been mired in violence and poverty for centuries, and political roads to modernisation and improving the human condition had only triggered more violence — most recently in the July Revolution of 1830. His solution: divert military funds to building a transcontinental railway and steamship network, the British high tech of the time. This would liberate humans from political, economic, and natural constraints; unite peoples across nations, continents, class, and natural boundaries in common economic collaboration creating prosperity for all; and produce peace, for why attack those on whom one's prosperity relies. The message resonated widely. For example, young so-called 'state engineers' in the newborn Belgian nation cited Chevalier when initiating the world's first national railway network as 'an intimate link between future prosperity and the independence of the nation' (de Block, 2011: 89). And in the Netherlands, from which Belgium was separated, Chevalier was translated in the context of similar railway debates in the 1830s. Note that the translation's title did not follow the original *Système de la Méditerranée* [The Mediterranean System] but read *De ijzerbanen beschouwd als de voornaamste materiele middelen ter bevestiging van den vrede in Europa, en ter bestendiging van het geluk des menschdoms* [Railways, considered the most important means for peace in Europe and happiness for humanity]. The universalistic promise that technology creates prosperity and peaceful collaboration for 'humanity' subsequently accompanied connective technologies from telegraphy and telephony, electricity supply, motorways and aviation to the internet and social media (Högselius, Kaijser, van der Vleuten, 2015).

Some two decades later, the discourse of promise had taken firm root and was showcased in an even more iconic event — the Great Exhibition of the Works of Industry of All Nations of London in 1851. The first world expo put on display the promise of every thinkable breakthrough in technology and captured the imagination of its six million visitors and many more through reports of the event that followed. While Chevalier's version of technology's promise had focussed on prosperity and peace, the exhibition suggested much more concretely how a wealth of technologies would improve workers', public, and domestic lives. Newspaper editor Horace Greeley summarized the message in his *Art and Industry* (1853: 52):

> [i]n our discoveries in science, by our applications of those discoveries to practical art, by the enormous increase of mechanical power [...] we have [...] given to Society at large, to almost the meanest member of it, the enjoyments, the luxury, the elegance, which in former times were the privilege of kings and nobles (capitalisation in the original).

Among the many visitors, foreign engineers and government officials took the promise back home to their respective countries, seeking to emulate the apparent success story.

This universal promise to 'humanity' and 'society' tended to obscure notions of social difference and inequality. It is therefore important to observe how diverse historical actor groups appropriated this discourse and translated it into specific innovation agendas fitting their own contexts and priorities. These appropriations partly overlapped and partly emphasized conflicting interests (van der Vleuten, Oldenziel, Davids, 2017).

For example, the discourse was adopted in very different political settings. The Belgian railway project already illustrated how national governments and state engineers throughout the subcontinent and beyond wed the promise of technology to political nationalism. National governments established ‘state engineering’ or ‘public works’ agencies (often modelled after the French *Corps des ponts et chausées*) executing or coordinating (through subsidy and concession schemes) the construction of national railway, waterway, roadway, and telegraphy networks, turning the nation into an economically competitive and politically governable entity. Thus emerged what has been called the ‘infrastructure state’ (Guldi, 2012). Urban governments likewise translated the promise to a municipal context: they set up municipal engineering departments or appointed city engineers to tackle such urban problems as health hazards and the unruliness of over-populated cities. In the famous words of Baron Georges-Eugène Haussmann (1809-1891) for the case of Paris, the point was to ‘regularize the disordered city, to disclose its new order by means of pure, schematic layout [...] to give unity to and transform the operative whole’ (as cited in Graham, Marvin, 2001: 55). That sentiment spread rapidly through international urban governance, engineering, and hygienist conferences. Though few city councils proceeded by means as radical as Haussmann’s, many turned private roads into public spaces; replaced mazes of dead-end streets with thoroughfares with piped water supply, sewage, and possible tram rail, gas, and electricity infrastructure; and made ungovernable or rebelling quarters accessible to police enforcement (Hård, Misa, 2008).

By contrast, nascent experiments in transnational and global governance in the form of international engineering organisations and networks nominally adopted Chevalier’s global ambitions of forging global telegraphy, railway, postal, geodetic, meteorological, and other connections to the benefit of ‘humanity’; yet in practice these were often ‘European’ organisations where engineers and diplomats negotiated notions of global progress with mundane national interests. And in a fourth and extremely influential political appropriation, colonial administrations adopted the discourse of promise for governing British, French, Dutch, Portuguese, Spanish, Italian, Belgian, German, Danish, and Russian colonies. Railways, telegraphy, the postal system — the three great engines of social improvement as the Governor General of India called them — and more became core to Europe’s ‘civilizing mission’, also involving the violent subjugation of colonial subjects at a time when Europeans governed more than eighty per cent of the globe (1914). Resistance groups therefore discovered an entirely different purpose of these technologies — as targets for sabotage and attacks (Kaiser, Schot, 2014; Högselius, Kaijser, van der Vleuten, 2015; Diogo, van Laak, 2016).

Businesspersons took the discourse of promise to a very different arena: whether or not they bought into political promises of social progress, technology certainly provided new business opportunities. The world’s first public railway — the Liverpool–Manchester line of 1830 — had been initiated by corn and textile merchants seeking to decrease transportation times and costs. But when the railway company itself unexpectedly provided high returns on investment, investors and entrepreneurs discovered the railway company as a business opportunity in itself, igniting a railway boom that engulfed Britain and the world (British, and to a lesser degree French, Dutch and other shareholders, owned most of the world’s technological infrastructure by 1914). This was a very different business model from Chevalier’s idealistic diversion of military funds to infrastructure construction. Entrepreneurs and investors now closely followed science and technology breakthroughs in search of new opportunities, innovating traditional industries — such as the textile industry — and establishing entirely new ones such as the chemical and electrotechnical industries. The tech-firm ousted trade firms in the business landscape and did so in close interaction with the expansion and diversification of engineering from civil, mechanical, and construction engineering to e.g. chemical, electrotechnical, and industrial engineering. Large tech firms pioneered research labs and patent offices that further boosted their business fortunes.

Various user communities took technology’s promise in still different directions, often seeking utility, entertainment, or empowerment for specific groups. For example, critics found that modern technology only delivered its promise to urban elites and middle classes. In response labour unionists, feminists, nutritionists, and others teamed up to take technology to the working class, and also to change hierarchical relationships between men and women and masters and servants. For example they developed communal social housing and facilities like shared kitchens, launderettes, stoves, and refrigerators. In a similar vein, farmer communities lamented how cities modernized and grew while the countryside became impoverished and depopulated. They searched for affordable power sources and machinery to reinvigorate rural economy and life; Poul la Cour's (1846-1908) wind-electric turbine and cooperatively owned village power stations to electrify the Danish countryside are a good example (Oldenziel, Hård, 2013; Hansen, 1985).

In sum, diverse and often antagonizing groups appropriated the universalist discourse of promise for very different contexts. Ironically, by taking the promise in so many different directions, they jointly built the 'universality' of the promise; as modern technology pervaded public and private life, many experienced great leaps in living conditions, personal health, income, education, and more, at least in Western Europe. These changes came with the invention, institutionalisation, and reputation of the profession of engineering. There was disagreement about what 'engineering' was (science-based engineering taught at of the *École polytechnique* in Paris vs. shop floor training in the 'practical arts' in the UK, for instance), how it should relate to politics, and who could practice (e.g. should women be admitted?). But many agreed that 'the engineer is the king of our epoch', as the 1873 edition of the Larousse encyclopedia stated (as cited in Kohlrausch, Trischler, 2014: 65–66).

Broken Promises

The long nineteenth century saw its share of technology conflicts and failures, from early-nineteenth-century Luddism to the high-profile sinking of the Titanic at the eve of the First World War. Yet only in the decades following 1914 critique of technology became so prominent that it could challenge the dominant discourse of promise. Dystopian technology discourse came to stay, and never again could utopian technology discourse claim the stage alone.

The most visible instances of technology's broken promises during Europe's thirty-year crisis, undoubtedly, include two World Wars, the Holocaust, colonial violence, and the global economic crisis of the 1930s. Chevalier's influential notion that technological development and collaboration could forge peace was decisively compromised by the use of technology in war: the First World War was the first to be called 'an engineer's war' with reference to the introduction of machine guns, chemical warfare, tanks, bomber planes, electrocuting fences, and much more (Christie, 1922: 99). One might counter that those technologies were applied on comparatively modest scales, and in many respects the Great War was fought using traditional means. However, Chevalier's 'railroads for peace' were key to the unprecedented massacres in the trenches. Behind trench warfare were modern logistics: railways and modern telecommunications continued to feed tremendous amounts of soldiers, ammunition, and food into the Western front from both sides, like two giant conveyor belts. This tragedy had been long in the making. As a French senator, Chevalier had witnessed the military perversion of his life's work in the Franco-Prussian war of 1870. Prussia beat the French army within months using superior militaries logistics: railroads and telegraphy moved troops effectively to outnumber the French in every vital battle. Following that display of military might, all militaries on the subcontinent radically reformed military strategy around logistics. And as they formed alliances and anticipated each others' Military Travel Plans, a tightly coupled system of prescheduled and interlocking military actions emerged. It was triggered in 1914 and got unexpectedly stuck in trench warfare; the logistics machines, however, kept feeding in soldiers, producing some of the deadliest battles in human history (Bucholz, 1994).

Examples of technology's role in co-producing violent wars abound. Iconic is the story of chemist Fritz Haber, who received the 1918 Chemistry Nobel Prize for the nitrogen synthesis that binds atmospheric nitrogen to hydrocarbons — which was used in artificial fertilizers that helped feed starving world populations. But when German military command asked Haber to save the fatherland, the 'maker of bread from air' became 'Dr. Death', the inventor of chemical warfare. Haber was not alone in this endeavour; the German initiative was a response to French experiments with poison gas shelling, and soon all major militaries explored gas warfare — the American Chemical Society pledged the aid of its 15,000 members to the US chemical Warfare Service, for example. Similarly, the enthusiasm of theoretical physics discovering nuclear fission turned to the nightmare of nuclear warfare in the Second World War, which by then had already seen the technological horrors of carpet bombing, rockets, and of course the Holocaust's logistics. The notion of European 'civilisation' became as tainted at home as its 'civilizing mission' was abroad — especially after missionaries and journalists exposed the torture, rape, and killing by the Belgian colonial army in Congo Free State, the British machine gunning of unarmed men, women, and children in Amritsar (India), the French bombing a peaceful demonstration in Vinh (Vietnam), the Italian extermination-through-bombing policies in Ethiopia, and much more. No longer could Europe's technology be unproblematically depicted as a great civilizer, and Europe itself as 'civilized' (Kohlrausch, Trischler, 2014; Diogo, van Laak, 2016).

Chevalier's notion of technology producing 'joint prosperity' was equally overturned, perhaps most significantly so during the Great Depression of the 1930s. Scientific management, the star invention of the young discipline of industrial engineering, and conveyor belts were supposed to benefit both capital and labour, increasing productivity as well as wages. But under financial stress, factory managers used these techniques to cut labour costs, leading to mass layoffs and unemployment. Besides, speeding up conveyor belts stressed out the remaining workers; Charlie Chaplin's movie *Modern Times* (1936), about a conveyor belt worker loss of sanity, represented an experience widely encountered in the US and Western Europe. However, workers were not the only ones to suffer. Technology's promise to business and entrepreneurship also backfired as the entrepreneurial world experienced mass bankruptcies. Besides, inventor-entrepreneurs in smaller companies were increasingly squeezed out by larger tech firms with their research labs and patent lawyer units — unless they were willing to take a role as suppliers to larger firms.

Technology's promise to liberate peoples from political, economic, and natural constraints, too, was turned upside-down. That broken promise was experienced by various user groups who had embraced modern technologies for liberation and empowerment. Electrical appliances came with the new danger of electrocution and fires, and in the case of gas lightning, railways, and above all automobiles, death by technology became a widespread phenomenon. Motorists were increasingly seen as joy riders, speed maniacs, and killers responsible for spiking traffic deaths by the non-motorist majority, and were increasingly regulated. So were bicyclists and pedestrians, who were assigned to specific segments of the streets and fined if they did not comply. The experience of freedom had taken a beating (Tenner 1997; van der Vleuten, Oldenziel, Davids, 2017). On a higher level of abstraction, philosophers, social critics, and engineers argued that technology itself now systematically threatened human individuality and freedom. For example, one of Germany's most prominent engineers, Walter Rathenau (1867-1922), felt that modern men and women were turning into mere 'cogs' in modern production and consumption systems. As early as in 1913 he had written about a mechanisation of the world that produced a mechanisation of the spirit. The notion of the enslavement of modern humans was further elaborated by critics such as José Ortega Y Gasset (1883-1955), Oswald Spengler (1880-1936), and the early Frankfurter Schule, while at the same time the enslavement of humans by robots and machines became a prominent theme in science fiction novels (Hughes, 2004).

The prestige of engineering took a similar beating. It is perhaps telling that in science fiction, scientists and engineers had traditionally figured as heroes, but now they increasingly figured as villains — together with businessmen, politicians, and criminals (Hirsch, 1958). Matters got still worse when their complicity in totalitarian regimes was widely exposed — even if that complicity was widely enforced by authorities that persecuted those who insisted that totalitarian engineering was often 'bad engineering' and that demanding allegiance of engineering organisations in return for their continued existence (note that only a small minority of Germany's 222,000 engineers joined the Nazi party (Kohlrausch, Trischler, 2014)). It was no longer uncontroversial to claim that engineers stood on the right side of history.

A New Hope: Technocracy

Since the Second World War, several engineering discourses came to prominence that sought to rescue technology's benefits from its harmful potential. This chapter outlines the contours of two of these: the discourses of technocratic and participatory innovation.

Many today associate technocracy with a neglect of democratic accountability. However, in a postwar context, the technocratic innovation discourse centred on a different and very urgent political problem. Politicians of different stripes and commercial managers had only recently steered technology towards global war, worker exploitation, and a crash of the world economy. They had proven that technology was too dangerous a tool in their hands. In a postwar context of increasing nationalism and an emerging Cold War, this could lead to a Third World War — a nuclear war. Hence the call for a different breed of professionals to take charge. Engineers, architects, planners, and other expert groups were *not* trained to win battles of political ideology, moral righteousness, or profit-making. Instead, so it was argued, they were committed to scientific methods to define problems, analyse those problems, and optimize solutions.

Technocratic thought had deep roots into the nineteenth century (not least to Saint Simonianism and international organisations), and had gained a boost in the prewar technocracy movement, which had condemned political, financial, and criminal manipulation: tackling societal problems as engineering problems, 'there will be no place for Politics or Politicians, Finance or Financiers, Rackets or Racketeers' (Anon. 1937, p.3). In the postwar decades that notion gained ever wider currency, and experts gained an unprecedented mandate from politicians and the public to make key technology decisions. This was not a *carte blanche*; the relations between experts, politics, and business were complex and remain an important historical research topic. But discursively, technocracy became a respected governance approach associated with successful postwar reconstruction, the avoidance of a Third World War, and unprecedented economic growth with vast welfare growth, almost zero unemployment, and more equal wealth distribution than ever before.

In the technocratic innovation discourse, three features were key to salvaging technology's benefits from its harmful potential (van der Vleuten, Oldenziel, Davids, 2017). First, technology should be de-politicized and de-commercialized. The notion that experts — not politicians or businessmen — should set innovation agendas translated into what became known as the 'linear model of innovation', inspired by prewar corporate research lab experiences and new science policies in the United States. The technological innovation trajectory was to start with 'basic' or 'fundamental' research, where experts engaged in 'undirected research' of 'fundamental problems'. Next came 'applied research', which transformed basic insights into usable products and processes. Finally, these would result in increased economic growth, health, and social welfare. Some historians have mistakenly criticized this model for not corresponding to the reality of innovation and social change, but that was not at all the point of the model; its point was to create leeway for experts to set innovation agendas — even though in practice, experts had to negotiate (and compromise) that leeway with all kinds of political and commercial interests (Balconi, Bruoni, Orsenigo, 2010). Thus followed the establishment of national research councils making taxpayer money available to fundamental research, presided over by experts, and new structures of fundamental research institutes such as the German Max Planck Institutes, the French Centre national de la recherché scientifique institutes, and similar institutes even under the Spanish and Portuguese dictatorships. The Organisation for Economic Co-operation and Developmet OECD promoted the linear model to its Western members states, and international research institutes such as CERN and the European Space Research organisation emerged.

In tech firms, similar models were celebrated to empower research lab experts in setting corporate innovation agendas. Central laboratories should e.g. receive direct funding (instead of funding from the company's business units to perform specific tasks) and hire academics to do unguided research within fields where the company was active (e.g. solid state physics or molecular spectra in the case of the Philips Electronics, where the postwar central lab director, theoretical physicist Hendrik Casimir (1909-2000), articulated a rather detailed linear model of innovation). The findings could then be translated into specific targets through 'target research' (e.g. finding a substance with given properties) and prototyping. Innovations coming out of such expert-run central labs were then handed to the business division's 'factory engineering' and 'application research' labs to adapt products for mass production and user demands.

A second element of the technocratic saving of technology from harmful consequences was to technify politics — defining, analysing, and solving societal problems not by lobbying, voting, arguing, fighting, or profit optimizing, but through scientific methodology. A particularly prominent scientific method in this context was the so-called systems approach (Hughes, Hughes, 2000; Lundin, Stenlås, Gribbe, 2010). Societal and business problems were extremely complex because of many interacting technical, social, economic, and environmental issues. Societal problems should therefore be modelled as systems with interacting elements which could subsequently be simulated. Manipulating selected elements could reveal — often counter-intuitive — system level responses and therefore help find policy options that led to beneficial rather than destructive results, and to system optimisation. This methodology gained a decisive boost from Second World War British military experiences with Operations Research that simulated and optimized existing military systems; after the war experts — not least in the US, the UK, and Sweden — developed models for analysing and optimizing future systems (adding game theory, complex scenarios, and feedback loops in human–machine interactive systems in approaches such as systems analysis and system dynamics) for application to industrial problems (localisation, investment, employment, or market decisions), urban problems, national economic, transport and energy system planning, and even world problems — consider the modelling of human–earth system interactions by Jay Forrester and the MIT computer lab that was behind the influential Club of Rome report *The Limits to Growth* (1968 to 1972).

Third and finally, the technocratic innovation discourse emphasized the great need for many and responsible engineers to take a leading role in industry and government. Throughout the Western world and beyond, the number of engineering schools multiplied. These engineers should be quality decision makers and future leaders, and engineering curricula were adapted accordingly. For one, theory ousted practice; engineering was presented more as a science than an art. For Gordon Brown, dean at the Massachusetts Institute of Technology MIT — the educational institute that many Western European engineers now looked to for inspiration — education trained 'the engineer's ability to relate seemingly unrelated events of nature, whether abstract or tangible, in quantitative ways, to make new and useful theories, materials, devices, complex systems, and especially systems in which men interact with machines' (as cited in van der Vleuten, Oldenziel, Davids, 2017: 125). Such interdisciplinary human–machine system competences required engineering science but also social sciences, life sciences, and humanities training. Another indication of the call for responsible engineers was a marked change in ethical codes of engineering institutions. No longer was loyalty to employers or making things work the chief virtue of engineers. Instead, not least inspired by work of the German engineering society with professional philosophers to process the war-time experience of Nazi collaboration, the chief value became loyalty to the dignity of human life and service to fellow humans (Mitcham, 2009).

The Participatory Fix

Around 1970, the technocratic consensus reversed almost completely and gave rise to a fourth prominent technology discourse — the discourse of participatory innovation. Critique of technocracy was an important ingredient of that discourse. Part of this critique came from social movements and counterculture activists rebelling against what they called the dominant Western technological world view. Environmental activist organisations such as Friends of the Earth (1969) and Greenpeace (1971) lamented that postwar technological systems had been optimized for exploiting nature; civil rights activists found that minority viewpoints had been ignored, and that experts acted beyond the democratic control of elected politicians. The peace movement stressed how the military–industrial–university complex had produced the nuclear arms race and perverse weaponry used in the Vietnam war horrors. Social critics revamped older critiques and argued that systems approaches prioritized rationality and order by stifling emotions, free expression, and communality; they felt that instead, humans, not the system, should come first. And further, incumbent players undermined technocratic thinking. For example, the US Department of Defense study Project Hindsight was pivotal in the invalidation of the linear model of innovation, finding that merely three per cent of the 710 key events leading to twenty crucial weapon systems had come from basic undirected research; 97 per cent came from applied research (Hughes, 2004; Wise, 1985).

These different sources of critique shared a notion that expert-run 'closed systems' needed opening up to other people, issues, values, and approaches. The linear model of innovation was in effect reversed: use and application should be the starting point for setting research and innovation agendas and priorities. And in order to make that happen, citizens, users, and other stakeholders or their representatives should participate directly in technological decision making and design. After all, the argument ran, it was they — not experts speaking on their behalf — who understood their problems and future needs best. And besides, those who had to live with the consequences of technology surely had a democratic right to also shape that technology.

As in the case of the technology discourses described earlier, we may recognize many different appropriations of the notion of participatory innovation (van der Vleuten, Oldenziel, Davids, 2017). In national and local politics, for example, action groups organized protests to affect technology decisions about nuclear weapons and energy, motorways, airports, land reclamation projects, housing, and much more. Iconic for their success were the anti-nuclear protest marches drawing hundreds of thousands of protesters in many Western European countries in the late 1970s and early 1980s. Even before the 1986 Chernobyl disaster, nuclear energy policies were shelved, e.g. in Denmark and Austria, and several ongoing nuclear construction projects were cancelled, e.g. in Germany and Spain. While political protest often took a conflictual approach, a new breed of technology mediators sought to forge consensus amongst stakeholders. In their view, deliberation should produce a co-decision or co-design process. They developed the field of participatory technology assessment, which became influential e.g. in Denmark, the Netherlands, Germany, and Austria, and developed approaches such as citizen conferences to bring citizens voices to the technological decision making process, and roadmap or scenario workshops to initiate a conversation between corporate, environmental, and local stakeholders, forging a mutual understanding of each other's concerns and translating these into joint technological decision-making acceptable to all. And from the early1980s, neoliberal thinkers also appropriated the participation discourse in still a different manner. That particularly influential appropriation opposed the left-wing notion of participation as a political right and posed that the welfare state made people passive onlookers waiting for the state to solve any problem they might experience. In the neoliberal vision of the 'participation society' consumer groups, patient organisations, companies, and other stakeholders would define and solve their problems themselves — and do so much more efficiently than the distant state apparatus could ever hope for. The neoliberal appropriation deeply politicized the notions of participation and participatory innovation, especially after cutting government expenses became an end in itself, and state functions were massively transferred to (often for-profit) private organisations.

Tech firms also appropriated the participatory innovation discourse in various ways. The linear model, as noted, was often reversed: management decided that henceforth business units would define innovation agendas based on marketing research and business opportunities, and hire central lab researchers to do specific research to that purpose. Innovation scholars recognized user innovation as a key resource for identifying future markets. Designers, for their part, appropriated the new discourse with notions such as user-centred design, including 'cooperative design' (coined by Scandinavian labour unions pioneering worker participation in e.g. factory automatisation processes) and 'participatory design' (coined in the US in the context of introducing personal computing at the workplace). And action groups managed to press boardrooms to adopt Corporate Social Responsibility programmes. Finally, corporate research leaders opened up closed innovation systems; the notion of 'open innovation' suggested that multiple companies pool research and innovation resources and form innovation ecosystems.

Outside the commercial settings of tech companies, user communities, too, reclaimed agency and initiated a host of activities. The technocratic innovation narrative had induced user representatives to present themselves as 'experts' and as such join expert committees for developing social housing, for example. But in the participatory age, all kinds of user communities started, once again, to define and solve their own problems. Initiatives ranged from Danish schoolteachers and alternative energy groups (re)starting the grid-connected wind-electric turbine success story to later renewable energy communities; from Do It Yourself hardware for house improvement to the small house movement; from biketivists reclaiming automobile-congested urban streets to today's revival of cycling as a sustainable urban mobility mode; and from the 1970s suburban garage home computer builders to open-source software and app design by users.

Finally, the engineering community itself appropriated the participatory innovation discourse from the very start, when young engineers started to rebel and were at the forefront of all kinds of alternative technology movements. By the late 1960s older engineers also recognized that a humanizing technology turn was imminent and that engineering institutions also needed to 'open up' (Wisnioski, 2012). Initiatives ranged from establishing technology and society divisions at major engineering associations and Science Technology and Society programmes in engineering schools to increasing the enrolment of women in engineering education. In the technocratic age women's enrolment had been encouraged to increase the number of engineers, but in the context of so-called differential feminism this enrolment also had connotations of bringing 'female values' into engineering. The science shop movement of the 1970s promoted socially engaged students and professors to work on real-life practical problems posed by disadvantaged citizens, financially weak worker groups, or civil society groups; the idea spread in the 1980s across Western Europe and beyond the university world. While the European Commission in the early 2000s praised the initiatives for interdisciplinary cooperation on problems that mattered, in the Netherlands, where the movement had originated, the neoliberal turn meant that idealistic science shops disappeared or changed into 'knowledge valorisation centres'. And with reference to the non-European world, the 'intermediate technology' or 'appropriate technology' movement sought to develop local solutions with and for local communities in the global South — solutions that preferably could be locally constructed, with local materials, and be locally maintained. Organisations such as Engineers Without Borders had similar agendas and were often student-led. These initiatives, too, increasingly felt the pressure on idealism of the neoliberal turn.

Today, technocratic and participatory innovation discourses often co-exist and mingle in novel ways. It is widely acknowledged that both had their strengths and weaknesses; both could be hijacked by political and commercial interests, for example. Current Grand Challenges for Engineering and 'save the planet through technology' discourses therefore call for the exploration and development of novel, nonlinear ways to govern technological decision making and design that would ideally combine the best of both worlds.

In the meantime, a global history of technique that seeks to escape 'universalistic' Western technology models and restore the plurality of technology meanings is certainly needed — especially at a time when global North-born concepts such as sustainable innovation, responsible innovation, and the Anthropocene once again seem to project global North priorities on global South situations with little regard for the plurality of ways of being, knowing, and relating that imply diverse problem definitions and solution search directions. Still, such a global history of technique also needs to consider that supposedly universalistic 'Western' technology discourses differed through time, have been appropriated very differently by diverse social groups, and remained thoroughly contested also 'back home' in Western Europe. Thus emerges a major challenge for global historians of technique: how to study the connected histories of technology and socio-ecological challenges in different places in the world in ways that simultaneously appreciate regional diversity and distinctiveness as well as transregional and transcontinental connections — material, institutional and discursive — that bring distant regional histories into mutual conversation (van der Vleuten 2019, 2020; de Hoop et al. 2022).

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